

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

Confirmation No.: 1461

In re Appellants : Yasuhiko Kojima, et al.
U.S. Serial No. : 10/591,476
Filed : September 1, 2006
Examiner : Mandy C. Louie
Group Art Unit : 1715
For : Copper Film Deposition Method

APPEAL BRIEF

Mail Stop
Appeal Brief – Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I. REAL PARTY IN INTEREST

The present application is assigned to TOKYO ELECTRON LIMITED, a corporation of Japan having a place of business at 3-6, Akasaka 5-Chome, Minato-Ku, Tokyo-To, JAPAN.

II. RELATED APPEALS AND INTERFERENCES

To the best of the undersigned's knowledge, no other appeals or interferences will directly affect, will be directly affected by, or will have a bearing on, the Board's decision in this appeal.

III. STATUS OF CLAIMS

Claims 2-14, 17-18, and 20-24 remain pending in the application, and are under appeal. These claims are attached to this Brief, as required by 37 CFR 41.37(c)(1)(viii). Claims 15-16 were withdrawn as being directed to a non-elected invention. Claims 1 and 19 were cancelled.

Independent claim 2 and its dependent claims 5-7 will stand together. Independent claim 3 and its dependent claims 4, 17, 18, and 20 will stand together. Independent claim 8 and its dependent claims 12-14 will stand together. Claim 11 will be argued separately. Lastly, independent claim 9 and its dependent claims 10 and 21-29 will stand together.

IV. STATUS OF AMENDMENTS

An Amendment was filed on February 16, 2010. The Amendment was entered. A Final Rejection was mailed on May 21, 2010. No subsequent amendments have been filed.

V. SUMMARY OF CLAIMED SUBJECT MATTER

Claim 2 is directed to a film deposition method for depositing a film onto a substrate. The first step of this method involves supplying a source material including a copper carboxylic acid complex or derivative onto a substrate. *See, e.g.*, page 3, lines 11-14. As a second step, the supply of source material is stopped and a reductive gas is supplied to the substrate. *See, e.g.*, page 3, lines 14-15. These two steps are alternately and repeatedly applied to deposit a film onto the substrate. *See, e.g.*, page 3, lines 16-17.

Claim 3 is directed to a film deposition method for depositing a film onto a substrate wherein the substrate is first placed into a process container and then the following four steps (A) – (D) are repeated. *See, e.g.*, page 3, lines 20-22. *See also*, Figs. 1 and 2.

Step (A) of the method involves supplying a source material including a copper carboxylic acid complex or a derivative onto the substrate. *See, e.g.*, page 3, lines 23-25. Step (B) involves stopping the supply of source material and removing the residual gasses from the process container. *See, e.g.*, page 3, lines 25-26. Step (C) involves supplying a reductive gas to the substrate. *See, e.g.*, page 3, lines 26-27. Step (D) involves stopping the supply of reductive gas and removing the residual gasses from the process container. *See, e.g.*, page 3, lines 27-29. These steps are repeated as desired. *See, e.g.*, page 3, line 22; Fig. 2.

Claim 8 is directed to a film deposition method for depositing a film onto a substrate by alternately and repeatedly performing the following two steps: (1) supplying a copper-containing source material to the substrate and (2) supplying a reductive gas to the substrate, after supply of the copper-containing source material has been stopped. *See, e.g.*, page 3, lines

32-36. At the beginning of the method (in the “first film deposition period”), step (2) of the method is performed for a given time, T1. (i.e., the duration that the substrate is subjected to the reductive gas lasts for a given time, T1.) *See, e.g.*, page 4, lines 1-4. Later in the method (in the “second film deposition period”), the substrate is subjected to the reductive gas for shorter period of time, T2. That is, the duration of step (2) is reduced to T2. *See, e.g.*, page 4, lines 4-8. *See also* Fig. 4.

Claim 9 is directed to a film deposition method for depositing a film onto a substrate wherein the substrate is first placed into a process container and then the following four steps (A) – (D) are repeated. *See, e.g.*, page 4, lines 11-14.

Step (A) of the method involves supplying a copper-containing source material to the substrate. *See, e.g.*, page 4, lines 14-15. Step (B) involves stopping the supply of source material and removing the residual gasses from the process container. *See, e.g.*, page 4, lines 15-17. Step (C) involves supplying a reductive gas to the substrate. *See, e.g.*, page 4, lines 17-18. Step (D) involves stopping the supply of reductive gas and removing the residual gasses from the process container. *See, e.g.*, page 4, lines 18-19.

At the beginning of the method (in the “first film deposition period”), step (C) of the method is performed for a given time, T1. (i.e., the duration that the substrate is subjected to the reductive gas lasts for a given time, T1.) *See, e.g.*, page 4, lines 1-4. Later in the method (in the “second film deposition period”), the substrate is subjected to the reductive gas for shorter period of time, T2. That is, the duration of step (C) is reduced to T2. *See, e.g.*, page 4, lines 20-27. *See also* Fig. 4.

Claim 11 depends directly from Claim 8 and limits the method as follows: (1) the first film deposition period continues until the copper deposited on the substrate becomes a continuous film, and (2) the second film deposition period continues until the copper film on the substrate achieves a desired thickness. *See, e.g.*, page 5, lines 7-13.

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

The following issues are presented for consideration in this appeal:

- 1) Whether claim 2 is unpatentable under 35 U.S.C. §103(a) as being obvious in view of Mouche et al., "Metal-organic chemical vapor deposition of copper using hydrated copper formate as a new precursor" ("Mouche") taken with U.S. Patent Application Publication No. 2002/0013487 to Norman et al. ("Norman");
- 2) Whether claim 3 is unpatentable under U.S.C. §103(a) as being obvious in view of Mouche and Norman, and further in view of U.S. Patent Application Publication No. 2001/0002280 to Sneh ("Sneh");
- 3) Whether claim 8 is unpatentable under 35 U.S.C. §103(a) as being obvious in view of Norman and U.S. Patent Application Publication No. 2003/0129308 to Chen et al. ("Chen");
- 4) Whether claim 9 is unpatentable under 35 U.S.C. §103(a) as being obvious in view of Norman, Chen, and Sneh; and
- 5) Whether claim 11 is unpatentable under 35 U.S.C. §103(a) as being obvious in view of Norman and Chen.

VII. ARGUMENTS

A. CLAIM 2 WOULD NOT HAVE BEEN OBVIOUS IN VIEW OF MOUCHE AND NORMAN

Appellants' claimed invention balances the competing objectives of faster growth of a high quality (copper) film, without compromising film quality. Claim 2 (and independent claim 3) focuses on the requirement of a source material that meets the objective of obtaining an excellent quality film, with very low surface roughness, in a sequential, alternating (ALD) process. Accordingly, claim 2 (and claim 3) recites a Cu-carboxylic acid complex (or a derivative thereof) as a source material that (i) produces high vapor pressure while used, (ii) has a high wettability to substrates, and (iii) has high polarity. *See Appellants' specification, ¶ [006].* Characteristic (i) of Cu-carboxylic acid complex ensures that Appellants' film

deposition method progresses at high source material gas concentration. Characteristic (ii) ensures that the resulting film will be a continuous, smooth Cu film of high quality, even at very small film thicknesses. And, characteristic (iii) ensures that deposition will progress at a high rate. Nothing in the asserted art, namely Mouche and Norman, discloses use of a Cu-carboxylic acid complex, as described in claim 2, to meet criteria (i) – (iii).

According to the Final Office Action dated May 21, 2010, Mouche teaches a chemical vapor deposition (“CVD”) film deposition method involving a source material containing a copper carboxylic acid complex, namely hydrated copper formate. The Final Office Action concedes that Mouche does not teach the supplying of a reductive gas to the substrate, or the alternating of steps between supplying the copper carboxylic acid complex and the reductive gas. It then cites the Norman disclosure for teaching an atomic layer disposition (“ALD”) film deposition method wherein a copper complex or derivative thereof is used as a source material. The Final Office Action further cites Norman for the alternate supplying of the copper complex and the reductive gas.

For at least the reasons set forth below, Appellants respectfully submit that claim 2 would not have been obvious to a person of ordinary skill in the art in view of Mouche and Norman.

1. The Combined Teachings of Norman’s ALD Process with Those of Mouche’s CVD Process Would Not Have Led A Person of Ordinary Skill in the Art to Appellants’ Claimed Sequential Process

Mouche teaches conventional CVD with hydrated copper formate as a source material. Norman teaches ALD with specific copper complexes (but not a Cu-carboxylic acid complex) as the source material gas, which source material gas alternately is applied to a substrate with a reductive gas. *See ¶ [0024].* Considered together, Mouche and Norman constitute persuasive evidence that one of ordinary skill in the art would not have substituted a Cu-carboxylic source material in an ALD process such as in Norman.

Mouche was published in 1995. Despite Mouche's investigation of conventional CVD with a Cu-carboxylic acid complex at least as early as 1995, no prior art since has described use of a Cu-carboxylic acid complex, or its derivatives, as sequential, alternating process (ALD) source material. This telling absence of any description of a Cu-carboxylic acid complex as a precursor in such a sequential process, since at least Mouche's time, is forceful evidence of the patentability of present claim 2. The contents of Norman do not rebut this evidence, but rather support it.

The Norman patent claims priority back to a provisional application that was filed more than four years after Mouche was published. Yet Norman makes no mention of Cu-carboxylic acid complexes or derivatives thereof, and instead discloses and claims a "new family" of compounds for use in ALD, or CVD. Norman does not even list Cu-carboxylic acid complexes in its list of three prior art categories set out in paragraphs [0002] through [0010]. Norman thus supports the proposition that nothing before Appellants' disclosure suggested Cu-carboxylic acid complexes in a method like instant claim 2. Hence, given Mouche's use of a Cu-carboxylic acid complex in CVD in 1995, given no prior art disclosing application of such a complex to ALD after Mouche, and given Norman's failure to recognize such complex as a source material candidate, the conclusion must be reached that none of Norman, Mouche or the art intervening between them suggested use of a Cu-carboxylic acid complex in the sequential process of claim 2, to those of ordinary skill in the art.

The fact that the prior art has been silent on use of Cu-carboxylic acid complex in alternating sequential processes, until Appellants' invention, directly is related to the nature of such ALD processes. Appellants' process of claim 2 forms a Cu film, of a desired thickness, layer-by-layer on an atomic or molecular level by alternately repeating a step of adsorbing their Cu-containing source gas and a step of reacting the adsorbed gas with their reductive gas to obtain a Cu film of desired thickness. This manner of layer-by-layer growth makes ALD susceptible to conditions that are of relatively little consequence in conventional CVD. For instance, as discussed in Appellant's specification, in a sequential atomic level process, if the copper complex source gas has low wettability with respect to a film-formation substrate, the

copper source material may aggregate on the substrate. If the nuclear density of copper in the early stage of the film deposition process is low, the resulting copper film will have a rough surface. *See specification ¶ [0005].*

The foregoing problems of alternating, sequential film-formation (ALD) are completely ignored by Mouche because Mouche teaches conventional CVD. Norman does not somehow remedy these deficiencies of Mounche, because, given, the extreme sensitivity of ALD as opposed to conventional CVD processes, those of ordinary skill in the art would have found no reason to use a copper carboxylic complex in an ALD process. Norman is explicit in teaching its particular novel family of copper complexes for ALD. Otherwise, according to Norman, the ALD process could be subject to the problems of mechanical adhesion, poor electrical contact, and CVD chamber contamination discussed toward the end of each of paragraphs [0005], [0008], and [0012] of Norman. Nothing in Norman would have induced those of ordinary skill to depart from Norman's compounds and then risk confronting the adhesion, poor electrical contact, and chamber contamination problems of which Norman warns. Nothing in Norman suggests to those of ordinary skill to stray from Norman's compounds toward Mouche's hydrated copper formate, or any other copper carboxylic acid complex, as called for in instant claim 2. Nothing in Norman suggests that nonproblematical ALD film growth could be accomplished by other than Norman's own novel compounds. Hence, Norman would not have led one of ordinary skill in the art to deviate from Norman's new copper complex family to substitute a copper carboxylic acid complex therefor, simply because such a complex was suggested for conventional CVD use by Mouche.

The Final Office Action asserts that a person of ordinary skill in the art would have been motivated to combine Norman and Mouche "in order to effectively control the film results to yield desirable properties." Yet the Final Office Action does not cite any teachings as to what these "desirable properties" would be, nor does the Final Office Action cite any teachings in Mouche (or Norman) as to how a source material containing a copper carboxylic acid complex would lead to desirable properties – in an advanced ALD process. A close examination of Norman demonstrates why the Final Action did not cite any such teachings. Norman's focus is

improving ALD by using the novel compounds discussed therein, instead of the prior three categories of CVD copper precursors that Norman discusses in paragraphs [0002] through [0010]. Appellants' copper carboxylic acid complex is completely outside the scope of Norman. Hence, Norman offers no guidance and no suggestion, to those of ordinary skill, that the hydrated copper formate of Mouche, or any other copper carboxylic acid complex, would provide acceptable results in ALD, let alone the unexpected superior results yielded by Appellants' process of claim 2. Hence, neither Mouche nor Norman could have provided any motivation or suggestion for combining them in a way obtaining the claimed invention.

Contrary to the position of the Final Action, Appellants respectfully submit that a person of ordinary skill in the art would have been left to no more than lengthy trial and error in order to have modified a sequential (ALD) process to utilize a copper carboxylic acid complex as a source material. Nothing in Mouche or Norman would have taught or suggested that Norman's ALD process could be modified to incorporate use of the hydrated copper formate as taught in Mouche's conventional CVD process.

Lastly, Appellants emphasize that their Japanese counterpart application includes independent claims whose scope is essentially the same as instant claims 2, 3, 8, and 9, and that their counterpart has been granted. During the prosecution of their Japanese counterpart application, the Krupoder et al. article cited in the (first) Office Action of October 11, 2009 was asserted with Mouche against original claim 7. Although Norman was not cited in the Japanese prosecution, Appellants are confident that the Japanese Examiner was aware that Cu film deposition by an ALD process like Norman was known in the art. Appellants submit that, in allowing the claims of their Japanese counterpart, the Japanese Examiner regarded the use of a Cu-carboxylic acid complex (or a derivative thereof) as a Cu source material, in an ALD process to be novel and inventive because of the unexpected, and unpredicted advantages achieved therefrom.

2. Appellants' Process of Claim 2 Produces Unexpected Results

Appellants' specification discusses similar prior-art ALD processes and the drawbacks associated therewith:

There has been known the use of a β -diketonate complex or a derivative thereof as a source material (Refer to, for instance, JP 2003-138378A) in forming a Cu film by a CVD process. If a film is formed by a ALD process by using the β -diketonate complex as a source material, since the vaporized β -diketonate complex has low wettability to a base layer, aggregation of the β -diketonate complex may occur when adsorbing it to the base layer. Furthermore, since the nuclear density of Cu is low in the early stage of film formation, a Cu film having a rough surface is formed. Therefore, it is difficult to form an extremely thin Cu film.

See page 2, lines 1-12.

Like Appellants, Mouche recognized problems with β -diketonate as a CVD copper precursor. Mouche went on to do a "preliminary study" and concluded that its experiments "demonstrate the possibility of using hydrated copper formate as a precursor for copper MOCVD". *See page 5, the "Conclusion".* Mouche does not suggest experiments with such formate as a precursor in a sequential (ALD) process. Given Mouche's silence on ALD, from Mouche, those of ordinary skill in the art could make no predictions as to the suitability of hydrated copper formate, or any other Cu-carboxylic acid complex (or derivative thereof), for an alternating sequential (ALD) process.

Norman likewise recognized problems with β -diketonates. However, instead of applying the source material teaching of Mouche to an ALD process, Norman went on to develop and claim a whole new family of metal precursors. *See Norman at ¶ [0017].* This new family does not include Cu-carboxylic acid complex. Hence, from Norman, those of ordinary skill in the art likewise could make no predictions as to the suitability of hydrated copper formate, or any other Cu-carboxylic acid complex (or derivative thereof), for a sequential (ALD) process. Rather, it

was only Appellants who looked to Cu-carboxylic acid complexes and discovered their advantages in a sequential, alternating film growth.

Appellants' use of a copper carboxylic acid complex as a source material overcomes the drawbacks Appellants found in β -diketonates. Specifically, Appellants' source material provides for a film deposition method with increased throughput, a smoother film surface, and improved adhesion of the film to the base layer. *See, e.g.*, page 2, line 34 – page 3, line 1 and page 3, lines 11 – 17 :

Another object of the present invention is to provide a film deposition method that achieves both improvement in throughput of a film deposition process, and reduction in roughness of a Cu film and improved adhesion of the Cu film to a base layer.

[...]

According to the second aspect of the present invention, there is provided a film deposition method including the steps of: supplying a source material including a Cu-carboxylic acid complex or a derivative thereof onto a substrate; and supplying a reductive gas to the substrate after stopping supplying the source material, wherein the step of supplying the source material and the step of supplying the reductive gas are performed alternately.

See also, page 5, lines 16-29:

In the first to third aspects of the present invention, since the Cu-carboxylic acid complex or a derivative thereof used as a source material has a high vapor pressure, the adsorbing step can be performed by using a source material gas having a high concentration. Such a source material gas has high wettability to a base. Thus, it is possible to form a continuous, smooth Cu film with high quality, even if the film thickness is small. In addition, since the Cu-carboxylic acid complex or a derivative thereof has

high polarity and thus is adsorbed to a substrate efficiently, the film deposition rate is high. Furthermore, Cu-calboxylic acid complex or a derivative thereof can be readily produced, and the cost is advantageously low. In the second and third aspects of the present invention, since an ALD process is employed, a film having excellent quality and film-thickness accuracy can be obtained.

Each of Appellants', Mouche's, and Norman's disclosures recognizes problems with β -diketonates and then goes on to offer a different solution to such problems. Mouche investigated hydrated copper formate as a possible source material in a less sophisticated, less sensitive conventional CVD process, but not a sequential (ALD) process. Norman developed an entire "new family" of compounds for ALD. Meanwhile, Appellants applied Cu-carboxylic acid complexes to sequential (ALD) film growth. Each disclosure goes in a separate direction. Neither Mouche nor Norman would have suggested Appellants' direction. Appellants' invention of claim 2 (and claim 3) applied a completely different type of source material to a known ALD process, and achieved unpredictable, and unexpectedly superior results thereby. Neither Mouche nor Norman could have suggested Appellants' results to those of ordinary skill in the art. Hence, Appellants respectfully submit that their invention, as claimed in claim 2, produces unexpected results in comparison to the prior art, and that any *prima facie* case of obviousness has thus been overcome.

B. CLAIM 3 WOULD NOT HAVE BEEN OBVIOUS IN VIEW OF MOUCHE, NORMAN, AND SNEH

Appellants' restate and incorporate herein their arguments from Part A, *supra*. They rest on their Part A arguments for claim 3 because Sneh goes no further than Norman in the way of disclosing use of a Cu-carboxylic acid complex, or a derivative thereof, in an alternating, sequential (ALD) film-forming process. In regard to claim 3 (and claim 2), Sneh goes no further than describing an ALD process using a metal-containing precursor, that is not a Cu-carboxylic acid complex, and a reducing agent. The method of claim 3 produces the same unexpected,

advantageous results as claim 2. Hence, claim 3 is not obvious over the asserted combination of Mouche, Norman, and/or Sneh.

C. CLAIM 8 WOULD NOT HAVE BEEN OBVIOUS IN VIEW OF NORMAN AND CHEN

Appellants' claim 8 recites that the step of supplying a reductive gas to the substrate occurs for a longer time period (T1) during the first film deposition period than during the second film deposition period (T2). Claim 8 (and claim 9) specifically addresses the problem of improving throughput without degrading the film quality. As Appellants explain at page 2, lines 15-26 of their specification, if the reduction step time is shortened, but not in the way according to their claims, impurities such carbon may present on the interface between the substrate and the formed Cu film, whereupon the copper film easily is adversely affected by substrate oxidation, with the result that adhesion of the film to the substrate is compromised, and surface roughness of the film is increased. Appellants' method of claim 8 thus divides the deposition process into periods (T1) and (T2), and accordingly establishes growth of a very high quality film while the process supplies reductive gas for the longer period (T1), before switching over to the shorter period (T2). The Final Office Action admits that Norman "appears to be silent in teaching these limitations of claim 8." It then cited Chen, paragraphs [0055] – [0061] as rendering the (T1) and (T2) period feature of Appellants' claim 8 obvious.

1. The Cited Portions of Chen Do Not Teach or Render Obvious the Features of Claim 8

None of the cited Chen paragraphs specifically teaches that the time interval for the pulse of reducing gas ("T₂" in Chen) can be fixed at a relatively high value during the beginning of the process, and thereafter fixed at a relatively low value through to the end of the process. Chen's paragraph [0055], for instance, merely teaches those of ordinary skill in the art that the pulse of reducing gas ("T₂") can be of the same duration as the pulse of copper II β -diketonate compound ("T₁"). Paragraph [0056] leads those of ordinary skill away from Appellants' invention in that it

teaches, among other things, that the interval for applying the reducing gas can be reduced with each cycle. This contrasts with Appellants' invention where the interval for applying the reducing gas is fixed at one constant at the beginning of the process and a second, lower constant later in the process. Chen's paragraphs [0057]-[0058] discuss the periods of non-pulsing between pulses. Paragraph [0059] teaches that all pulses and non-pulses can have the same time interval. Paragraph [0060] teaches that the various pulses and non-pulses can differ from one deposition cycle to the next. Finally, paragraph [0061] teaches that the deposition process can cease when a film of desired thickness is achieved.

None of these cited portions of Chen discloses Appellants' specific regulation of reductive gas supply to a relatively long (and fixed) time interval at the beginning of the film deposition process, and to a relatively short (and fixed) time interval towards the end of the film deposition process. None of these passages in Chen discloses the reasons for Appellants' particular regulation. Appellants require relatively long reduction gas supply early in the deposition because it is this phase of the deposition process in which there is a great risk of lowering adhesion of the Cu film, and increasing its surface roughness, if the period (T1) for supplying the reductive gas is too short. Appellants thus claim it to be relatively long so as to establish an initial film with excellent quality. Appellants further discovered that thereafter, in their second film deposition period, there is such a reduced possibility of adhesion and roughness defects, that they claim time (T2) for supplying the reductive gas to be relatively short. According to their method, the quality of the complete Cu film is improved, and such quality improvement is achieved regardless of the type of Cu source material. Hence, Appellants do not limit claim 8 (or claim 9) to only Cu-carboxylic acid complex or its derivatives. They have succeeded in unexpectedly shortening the total time required for film deposition by dividing the deposition at a crucial point during the deposition and then shortening the time dedicated to reductive gas supply, during the second period in the film deposition, thus resulting in remarkably improved throughput.

In effect, Appellants' claim 8 (and claim 9) defines the narrow concept that reductive gas supply time must be regulated closely in particular phases of the film deposition, whereas, with

respect to the claimed invention, Chen teaches the broad concept that for all the ALD gases, including the reductive gas, the supplying times may be changed. Hence, in no way could Chen have targeted reductive gas supply time regulation to increase throughput in the way the Appellants' have done. In no way would Appellants' reductive gas regulation, or the advantages gained therefrom, have been apparent, or predictable, to one of ordinary skill in the art, from the teaching of Chen. It admittedly is not present in Norman. Therefore, Appellants respectfully submit that the asserted combination of Norman and Chen does not render obvious Appellants' claim 8.

2. Appellants' Invention as Claimed in Claim 8 Produces Unexpected Results

Appellants' submit that in disclosing their invention, as claimed in claim 8 (and claim 9) they demonstrate that their inventive methods confirm unexpected results. As stated in Appellants' "Background Art" portion of their specification, shortening the time interval for applying the reducing gas was known to create problems with the film:

The reduction reaction with the use of a reductive gas takes a long time. Thus, it is desirable to shorten the reduction-step time for improving the total throughput of the entire film-forming process. However, if the reduction-step time is shortened, impurities such as carbon originated from the source material gas are generated on an interface between the base layer and the Cu film, and the Cu film is easily affected by oxidization of the base layer, and therefore the adhesion of the Cu film to the base layer becomes lower and the surface roughness of the film becomes disadvantageously remarkable. It is thus difficult to achieve both improvement of the throughput by shortening the reduction-step time and improvement of the film quality.

See page 2, lines 15-26.

Appellants' process as claimed in claim 8 solves the above-described throughput versus film quality problem and produces unexpected results, namely a copper film of excellent quality produced in a shortened time period. *See, e.g.*, page 19, lines 17-29:

As described above, with this embodiment, in the first film deposition period in the early deposition stage in which there is a possibility of lowering of the adhesion of the Cu film and noticeable surface roughness, the period of time T1 for supplying a reductive gas is set relatively long to form an initial film with excellent quality; and thereafter in the second film deposition period in which there is no possibility of the foregoing defects, the time T2 for supplying the reductive gas is set relatively short. Due to this feature, the total time required for the film deposition process can be shortened in correspondence to the shortened time for the reductive gas supply step in the second film deposition period. Therefore, a conformal film with excellent quality can be obtained at high throughput.

See also, page 5, line 32 – page 6, line 12:

In the fourth and fifth aspects of the present invention, the period of time for the reduction reaction with the use of a reductive gas, preferably radicals thereof, performed in the early stage of the film deposition is set relatively long so as to prevent negative effects of impurities such as carbon originated from the source material which appear on an interface between the base and the Cu film or prevent negative effects of oxidization of the base, whereby a continuous Cu film with excellent quality is formed; and the period of time for the reductive reaction with the use of a reductive gas, preferably a radical thereof, performed in the later stage of the film deposition is set relatively short, whereby the time required for the later stage of the film deposition is shortened. Due to the above, the time required for the entire film deposition process can be shortened regardless of the type of the Cu-containing source material, and

thus both improvement of quality of a Cu film formed by the ALD process and improvement of the throughput of the process can be achieved.

In view of the foregoing unexpected results, Appellants submit that they have overcome any *prima facie* case of obviousness presented in the Final Office Action.

D. CLAIM 9 WOULD NOT HAVE BEEN OBVIOUS IN VIEW OF NORMAN, CHEN, AND SNEH

Appellants' restate and incorporate herein their arguments from Part C, *supra*. Sneh discloses nothing in the way of Appellants' division of the deposition process into periods of relatively long reductive gas supply and relatively short reductive gas supply. Therefore, Sneh cannot remedy the deficiencies of either Norman or Chen with respect to claim 9 (or claim 8). Claim 9 produces the same unexpected, advantageous results as claim 8. Thus the rejection of claim 9 is overcome.

E. CLAIM 11 WOULD NOT HAVE BEEN OBVIOUS IN VIEW OF NORMAN AND CHEN

Appellants' claim 11 depends directly from independent claim 8 and adds the feature that the first film deposition period continues until the copper deposited onto the substrate becomes a continuous film, and that the second film deposition period continues until a copper film of desired thickness is formed on the substrate. As stated in Part C, *supra*, Appellants submit that Chen does not teach or suggest the two film deposition periods claimed in Appellants' claim 8. However, the Final Office Action cites Chen, at paragraph [0061] as also teaching the added limitations of Appellants' claim 11.

The cited paragraph of Chen, however, merely teaches that Chen's process may end once the desired thickness of copper is formed on the substrate. Chen is silent about maintaining a first film deposition period until the copper formed on the substrate is a continuous film. Chen teaches no such transition time. That is, Chen does not teach or suggest that the pulses of reducing gas should be applied for a longer time interval until a continuous film of copper is

formed on the substrate, as claimed in Appellants' claim 11. Advantageously, Appellants' method produces a high quality copper film in a relatively short period of time. *See Appellants' specification, ¶ [0017], supra.* Appellants therefore submit that claim 11 is non-obvious in view of the cited prior art.

For the reasons set forth above, Appellants respectfully request that each of the rejections under 35 U.S.C. §103(a) be reversed.

This Brief is accompanied by the fee of \$540.00 as set forth in 37 C.F.R. § 41.20(b)(2). If any additional fees under 37 C.F.R. §§ 1.16 or 1.17 are due in connection with this filing, please charge the fees to Deposit Account No. 02-4300, Order No. 033082M343.

Respectfully submitted,
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Dated: April 15, 2011

MAM/DTH/cvj

VIII. APPENDIX

Pursuant to 37 CFR 41.37(c)(1)(viii), herein is a clean copy of Claims 2-14, 17-18, and 20-24, the claims involved in this appeal.

1. (Canceled)

2. (Original) A film deposition method comprising the steps of:

supplying a source material including a Cu-carboxylic acid complex or a derivative thereof onto a substrate; and

supplying a reductive gas to the substrate after stopping supplying the source material,

wherein the step of supplying the source material and the step of supplying the reductive gas are performed alternately.

3. (Original) A film deposition method comprising the steps of:

placing a substrate in a process container; and

repeating the following steps (a) to (d):

(a) supplying a source material including a Cu-carboxylic acid complex or a derivative thereof onto the substrate;

(b) removing residual gases in the process container therefrom after stopping supplying the source material;

(c) supplying a reductive gas to the substrate; and

(d) removing residual gases in the process container therefrom after stopping supplying the reductive gas.

4. (Original) The film deposition method according to claim 3, wherein the steps (b) and (d) are performed by replacing atmosphere in the process container with an inert gas, or by evacuating the processing container.

5. (Previously Presented) The film deposition method according to claim 2, wherein the reductive gas is converted into radicals by using plasma when the reactive gas is supplied to the substrate.

6. (Previously Presented) The film deposition method according to claim 2, wherein the reductive gas is H₂ gas.

7. (Previously Presented) The film deposition method according to claim 2, wherein the source material contains copper trifluoroacetate.

8. (Previously Presented) A film deposition method that alternately performs a step of supplying a Cu-containing source material onto a substrate and a step of supplying a reductive gas to the substrate after stopping supplying the Cu-containing source material, wherein said method has:

a first film deposition period in an early deposition stage in which the two steps are performed alternately and each of the steps of supplying the reductive gas is performed for a first period of time T1; and

a second film deposition period following the first film deposition period in which the two steps are performed alternately and each of the steps of supplying the reductive gas is performed for a second period of time T2 shorter than the period of time T1.

9. (Previously Presented) A film deposition method comprising the steps of:
placing a substrate in a process container; and repeating the following steps (a) to (d):
(a) supplying a Cu-containing source material onto the substrate;
(b) removing residual gases in the process container therefrom after stopping supplying the Cu-containing source material;
(c) supplying a reductive gas to the substrate; and

(d) removing residual gases in the process container therefrom after stopping supplying the reductive gas,

wherein said method has:

a first film deposition period in an early deposition stage in which the steps (a) to (d) are performed alternately and each of the steps of supplying the reductive gas is performed for a first period of time T1; and

a second film deposition period following the first film deposition period in which the steps (a) to (d) are performed alternately and each of the steps of supplying the reductive gas is performed for a second period of time T2 shorter than the period of time T1.

10. (Original) The film deposition method according to claim 9, wherein the steps (b) and (d) are performed by replacing atmosphere in the process container with an inert gas, or by evacuating the processing container.

11. (Previously Presented) The film deposition method according to claim 8, wherein the first film deposition period continues until Cu deposited on the substrate becomes a continuous film, and the second film deposition period continues until a Cu film with a desired thickness is formed on the substrate.

12. (Previously Presented) The film deposition method according to claim 8, wherein the first period of time T1 is in a range of 3 to 20 seconds and the second period of time T2 is in a range of 1 to 5 seconds.

13. (Previously Presented) The film deposition method according to claim 8, wherein the reductive gas is converted into radicals by using plasma when the reactive gas is supplied to the substrate.

14. (Previously Presented) The film deposition method according to claim 8, wherein the reductive gas is H₂ gas.

15. (Withdrawn)

16. (Withdrawn)

17. (Previously Presented) The film deposition method according to claim 3, wherein the reductive gas is converted into radicals by using plasma when the reactive gas is supplied to the substrate.

18. (Previously Presented) The film deposition method according to claim 3, wherein the reductive gas is H₂ gas.

19. (Canceled)

20. (Previously Presented) The film deposition method according to claim 3, wherein the source material contains copper trifluoroacetate.

21. (Previously Presented) The film deposition method according to claim 9, wherein the first film deposition period continues until Cu deposited on the substrate becomes a continuous film, and the second film deposition period continues until a Cu film with a desired thickness is formed on the substrate.

22. (Previously Presented) The film deposition method according to claim 9, wherein the first period of time T1 is in a range of 3 to 20 seconds and the second period of time T2 is in a range of 1 to 5 seconds.

23. (Previously Presented) The film deposition method according to claim 9, wherein the reductive gas is converted into radicals by using plasma when the reactive gas is supplied to the substrate.

24. (Previously Presented) The film deposition method according to claim 9, wherein the reductive gas is H₂ gas.

IX. EVIDENCE APPENDIX

No declarations or affidavits under 37 CFR 1.130, 1.131 or 1.132 were submitted.

X. RELATED PROCEEDINGS APPENDIX

There have been no decisions rendered in any related appeals or interferences.